REMARKS

Favorable reconsideration and allowance are respectfully requested. Claims 1-7 are pending in the present application, with claims 1 and 6 being independent. Claims 6-7 have been added by this amendment, which do not add any new subject matter.

Drawings

Applicants respectfully request that the Examiner indicate whether or not the drawings that were filed on January 26, 2001, have been accepted (see item 10 of the Office Action Summary).

Information Disclosure Statement

Applicants submit herewith a copy of the initialed PTO-1449 Form that was initialed and returned by the Examiner. Upon closer review of the PTO-1449 Form, it was discovered that the Examiner failed to initial a cited reference, namely U.S. 5,757,791. Thus, Applicants respectfully request that the Examiner initial this cited reference and return the PTO-1449 Form to the undersigned.

Specification

The Examiner objected to the specification because it does not contain an Abstract and because of the arrangement of the specification. Applicants submit herewith a substitute specification, placing the application into proper form for U.S. patent practice and in an effort to correct a few minor informalities. This substitute specification does not add any new subject matter.

Claim Objections

The Examiner objected to claim 4 because of a minor informality. Applicants have amended claim 4 in an effort to overcome this minor informality. Accordingly, withdrawal of the objection is respectfully requested.

Claim Rejections Under 35 U.S.C. §103

The Examiner rejected claims 1-4 under 35 U.S.C. §103(a) as being unpatentable over Peeters et al. (U.S. Patent 6,628,738) in view of Shirakata et al. (U.S. Patent 6,169,751). This rejection is respectfully traversed insofar as it pertains to the presently pending claims.

Independent claim 1 is directed to a process for processing OFDM-signals received substantially simultaneously by a multi-antenna system with two or more corresponding separate receiving channels. In each receiving channel, the I/Q-values of each individual carrier of the OFDM-signal are obtained and channel correction values or confidence values are determined from pilots for each carrier of the OFDM-signal. Weighting factors are thus derived from the channel correction or confidence values for each I/Q-value of each carrier and each receiving channel, by which weighting factors the I/Q-values of each individual carrier of the OFDM-signal obtained in the OFDM-demodulator are weighted such that I/Q-values of carriers received at a low level are weighted low and I/Q-values of carriers received at a high level are weighted high. The thus weighted I/Q-values are then added and divided by the number of all the weights.

Peeters et al. is directed to a method to determine a clock timing error in a multi-carrier transmission system in order to synchronize between a transmitting modem and a

receiving modem. Skirakata et al. is directed to an OFDM receiving apparatus that converts a received OFDM signal on the basis of two sampling signals to detect reference symbols that are intermittently inserted in the OFDM signal.

Applicants respectfully submit that the Examiner failed to establish a *prima facie* case of obviousness. To establish a *prima facie* case of obviousness, three basic criteria must be met: (1) there must be some suggestion of motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art to modify the reference or to combine reference teachings; (2) there must be a reasonable expectation of success; and (3) the prior art reference must teach or suggest all the claim limitations, see *In re Vaeck*, 947 F.2d 48, 20 USPQ2d 1438 (Fed.Cir.1991).

Applicants respectfully submit that the cited art fails to teach or suggest at least a multi-antenna system with two or more corresponding separate receiving channels, whereby weighting factors are derived and whereby I/Q values of each individual carrier are weighted, as generally recited in independent claim 1.

In other words, the present invention is generally directed to weighting and correcting receiving signals that are simultaneously received at the same frequency by different antennas. In contrast thereto, Peeters et al. teaches how individual carriers of one OFDM signal that are received with a different frequency can be weighted with weighting factors A, such that all carriers have the same phase, i.e., how the individual carriers of an OFDM signal can by synchronized in phase. Peeters et al., however, contains absolutely no teaching that for a system having two or more corresponding separate receiving channels, the I/Q values of each individual carrier of the OFDM-signal are obtained and that channel correction values or confidence values are determined for each carrier.

Furthermore, Applicants respectfully submit that Skirakata fails to make up for the above-identified deficiencies of Peeters et al. Thus, it should now be evident that the alleges combination of Peeters et al. and Skirakata fails to teach or suggest all of the features of at least independent claim 1, and therefore a prima facie case of obviousness cannot be substantiated.

Dependent claims 2-5 should be considered allowable at least for depending from an allowable base claim.

Accordingly, withdrawal of the rejection is respectfully requested.

New claims 6-7 should be considered allowable at least because the cited art fails to teach or suggest the combination of elements including that the added I/Q values are divided by the total weight to determine a mean value, the mean value being utilized to maximize the signal to noise ratio.
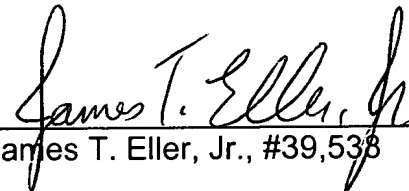
Conclusion

Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Martin R. Geissler (Reg. No. 51,011) at the telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future

replies, to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any

additional fees required under 37 C.F.R. §§ 1.16 or 1.17; particularly, extension of time fees.

Respectfully submitted,

BIRCH, STEWART, KOLASCH & BIRCH, LLP

By _____

James T. Eller, Jr., #39,538

JTE/MRG/mlr:tm
4100-0120P

P.O. Box 747
Falls Church, VA 22040-0747
(703) 205-8000

Attachments: Copy of PTO-1449 Form
Substitute Specification
Marked-up Version of the Original Specification
Abstract of the Disclosure

ABSTRACT OF THE DISCLOSURE

The aim of the invention is to process OFDM signals which are simultaneously received via a multiple antenna system having a plurality of separate receive channels. To this end, the channel correction values or the confidence values are determined in the receive channels for each carrier of the OFDM signal while using known techniques. In addition, the I/Q values of each individual carrier of the OFDM signal which are obtained in the OFDM demodulator are weighted with these channel correction values or confidence values. Afterwards, the I/Q values weighted in such a manner are totaled.

~~A Process for Processing OFDM-Signals Received Simultaneous by a Multi-Antenna System~~

A PROCESS FOR PROCESSING OFDM-SIGNALS RECEIVED SIMULTANEOUSLY BY A MULTI-ANTENNA SYSTEM

[0001] This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/EP99/07102, which has an International filing date of September 23, 1999, **and** which designated the United States of America.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The **present** invention relates to a process ~~according to the preamble of the Main Claim~~ **for processing OFDM-signals received simultaneously by a multi-antenna system with a plurality of separate receiving channels**.

2. Description of the Background Art

[0003] In modern digital technology, so-called OFDM-systems (Orthogonal-Frequency-Division Multiplex) or COFDM-systems (coded OFDM) are used for data transmission (sound, video or other data). In accordance with this principle, prior to transmission the digital data stream is split via a transmitter network into a plurality of sub-signals, each of which is transmitted separately on an individual carrier. In the so-called DVB-T-system (Digital-Video Broadcasting, terrestrial), which also serves for the transmission of data of a general type, 1705 or 6817 individual carriers are used for example. In the receiver these items of subsidiary information are recombined to form a

complete item of information of the transmitter-end digital data stream.

[0004] These OFDM-systems are standardized in terms of the transmitting-end conditioning and receiving-end recovery of the data (for example in the DAB-standard ETS 300401 for DAB and in the standard ETS 300744 for DVB-T). It is a common feature of these OFDM-systems that at the receiving end the high-frequency signal received by an antenna is demodulated in an OFDM-demodulator, preferably after conversion into an intermediate frequency, and in this way the associated I/Q-values are acquired for each individual carrier. In a so-called pilot-tone-corrected OFDM-system, as used in DVB-T, a channel correction value is determined simultaneously from the co-transmitted pilot tones. For each individual carrier, each I/Q-value is complexly multiplied by the relevant channel correction value. This ensures that all the carriers have constant amplitudes, possible breaks in amplitude of individual carriers of the overall reception band, caused for example by multipath reception disturbances, being appropriately compensated and corrected.

[0005] In such systems, in addition to the individual data, it is also common practice to transmit so-called confidence values and thus to influence the further processing of the acquired digital values in so-called soft-decision processes. These two known possibilities of correcting the I/Q-values via the channel correction or the obtained digital values through the confidence values are state of the art in receiver technology.

[0006] To improve the signal/noise ratio, in particular for the mobile reception of such OFDM-signals, it is known to provide a multi-antenna system with two or more antennae and correspondingly assigned, separate receiving channels, and to combine the analogue received signals in the receiver in the HF- or IF-plane of this plurality of

receiving channels. The analogue signals of the individual receiving channels are added, having been weighted in **a** frequency-dependent manner, for example, as a function of the received power. Here, however, not only the useful signals but also the noise components are combined, which in principle can even result in an impairment of the signal/noise ratio compared to the most favourable receiving channel for the relevant sub-band. These analogue combining processes also require a very high outlay and follow the relevant channel properties only relatively slowly. In the case of frequency-selective addition, they have only relatively flat selection curves, i.e. sharp breaks in the receiving frequency range cannot be corrected.

SUMMARY OF THE INVENTION

[0007] ~~Therefore the~~ **It is therefore an** object of the **present** invention ~~is~~ to indicate a process for combining OFDM-signals received simultaneously by a multi-antenna system which avoids these disadvantages and leads to a distinct improvement in reception.

~~Commencing from a process according to the preamble of the Main Claim, this object is achieved by the characterising features of the Main Claim. Advantageous further developments are described in the sub-claims.~~

[0008] In accordance with the invention, in each individual receiving channel of the multi-antenna system, the values for channel correction or confidence anyhow acquired therein according to the relevant standard are used for a corresponding weighting of the demodulated I/Q-values. In the DAB-system, in which the confidence values are determined in **a** known manner, these can be used in accordance with the invention to add the relevant I/Q-values in an appropriately weighted manner and thus, from the relevant

receiving branches having a good signal/noise ratio for the received signal, to obtain a corresponding mean value of the individual received signals of the multi-antenna system, which is particularly advantageous for the mobile reception of DAB-signals where, due to the properties of the transmission channel, a more difficult reception situation exists than in the case of stationary reception. In this way fading disturbances can be corrected.

[0009] It is particularly advantageous to perform this correction as a function of the channel correction values as provided in the DVB-T-system. Here again, mobile reception with a good signal/noise ratio is possible, this weighted evaluation of the received signals in the individual receiving channels facilitating a particularly simple analysis algorithm.

~~In the following the invention will be explained in detail in the form of two exemplary embodiments making reference to schematic drawings.~~

[0010] **Further scope of applicability of the present invention will become apparent from the detailed description given hereinafter. However, it should be understood that the detailed description and specific examples, while indicating preferred embodiments of the invention, are given by way of illustration only, since various changes and modifications within the spirit and scope of the invention will become apparent to those skilled in the art from this detailed description.**

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] **The present invention will become more fully understood from the detailed description given hereinbelow and the accompanying drawings which are given by way of illustration only, and thus are not limitative of the present invention, and wherein:**

[0012] FIG. 1 is a circuit diagram of the present invention according to a preferred embodiment;

[0013] FIG. 2 is a graph illustrating an example of weighting and adding for two antenna; and

[0014] FIG. 3 is a circuit diagram of the present invention according to an alternate embodiment.

DETAILED DESCRIPTION

[0015] Figure 1 is the fundamental circuit diagram of a receiving arrangement for processing pilot-tone-supported OFDM-signals in which the signals of the individual carriers of the multi-antenna system are digitally combined upstream of the decision device. The received multicarrier OFDM-signals are received via a plurality of antennae Al to An and can optionally be converted into a suitable intermediate frequency via individual receivers El, E2 to En. All the receivers El to En are set at the same receiving frequency and for simplicity the down-conversion into the intermediate frequency optionally can be performed using a common oscillator. Then, in each of the n receiving channels, the demodulation of the OFDM-signals is in each case performed in separate demodulators Dl to Dn and at the same time the associated channel correction values are also acquired, these being a gauge of the level of the individual carriers of the multicarrier system and thus also a gauge of the probability that the symbol transmitted with this carrier is correct.

[0016] The I/Q-values available for each individual carrier at the output of the demodulators are fed to a time synchronisation device S, in which possible time offsets of

the total number n of I/Q-signals are corrected by corresponding delay devices so that the I/Q-values of corresponding carriers occur simultaneously at the output of this time synchronisation device S, which values are then fed to a processing device R and processed therein as will be described in the following. The time synchronisation can be performed using synchronisation flags known in association with OFDM demodulators.

[0017] Before the I/Q-values, thus conditioned in known manner, are reduced to individual bits in the decision (demapping) device M, in the processing device R they are complexly multiplied by a value k proportional to the reciprocal value of the relevant channel correction, and thus are weighted. This weighting is firstly performed individually, for each I/Q-value for all n receiving channels. The I/Q-values are thus weighted particularly high if they are changed as little as possible by the channel correction. Then all the mutually assigned I/Q-values are added and divided by the sum of all the weights. Figure 2 illustrates this type of weighting and addition for two antennae A1 and A2. Of the total of 1705 or 6817 individual carriers of the system, at the frequency f1 the received carrier is received only with a reduced amplitude via the antenna A1 due to fading. This is expressed by the reciprocal value k1 of the channel correction obtained for this receiving channel. The carrier at the frequency f1 is thus weighted with a relatively low weight, for example only with the channel correction value 2, while the carriers in the range below and above the frequency f1, which are received at the full level, are weighted very high, for example with the weight 10. In the case of the antenna A2 this low weighted receiving range lies at a different location at the frequency f2.

[0018] When the I/Q-values, differently weighted in this way with for example 2 and 10 in the f1 range, are now added and finally divided by the total number of all the weights

(in the example 12), a mean value is obtained which has a constant good reception value over the entire frequency range. The averaged I/Q-values thus obtained in the processing device R are then fed to the decision device M and further analyzed therein in known manner. Optionally, the confidence of the information can also be calculated therein. Then the data are further processed in a conventional Viterbi-decoder V with soft decision.

[0019] Figure 3 illustrates an exemplary embodiment of a receiving arrangement for processing OFDM-signals in a multi-antenna system by digital combination downstream of the decision device M. In many cases the I/Q-values are available for further processing not upstream of the decision device but only downstream of the decision device M, which in this case for example is integrated in the demodulator Dl for each individual receiving channel. Thus the data words reduced to individual bits are already available at the output of the demodulator and indeed together with the confidence values which have likewise been calculated in the decision devices Ml to Mn and which, following the time synchronisation in the time synchronisation device S, are weighted and further processed in the processing device R as follows.

[0020] Each individual data word of the n receiving channels is reduced to the original I/Q-values using a suitable algorithm. The thus obtained, corresponding I/Q-values are then complexly multiplied by the value of the relevant confidence information, whereupon all the thus weighted I/Q-values are added again as described in association with Figure 2 and then divided by the number of all the weights. When the I/Q-values have been reduced to the data bits, the thus determined mean value of all the I/Q-values is then fed again to the Viterbi-decoder with soft decision V and further processed.

[0021] **The invention being thus described, it will be obvious that the same may be varied in many ways. Such variations are not to be regarded as a departure from the spirit and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.**

What is claimed is:

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A PROCESS FOR PROCESSING OFDM-SIGNALS RECEIVED
SIMULTANEOUSLY BY A MULTI-ANTENNA SYSTEM

[0001] This application is the national phase under 35 U.S.C. § 371 of PCT International Application No. PCT/EP99/07102, which has an International filing date of September 23, 1999, and which designated the United States of America.

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acquired for each individual carrier. In a so-called pilot-tone-corrected OFDM-system, as used in DVB-T, a channel correction value is determined simultaneously from the co-transmitted pilot tones. For each individual carrier, each I/Q-value is complexly multiplied by the relevant channel correction value. This ensures that all the carriers have constant amplitudes, possible breaks in amplitude of individual carriers of the overall reception band, caused for example by multipath reception disturbances, being appropriately compensated and corrected.

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SUMMARY OF THE INVENTION

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[0008]   In accordance with the invention, in each individual receiving channel of the multi-antenna system, the values for channel correction or confidence anyhow acquired

therein according to the relevant standard are used for a corresponding weighting of the demodulated I/Q-values. In the DAB-system, in which the confidence values are determined in a known manner, these can be used in accordance with the invention to add the relevant I/Q-values in an appropriately weighted manner and thus, from the relevant receiving branches having a good signal/noise ratio for the received signal, to obtain a corresponding mean value of the individual received signals of the multi-antenna system, which is particularly advantageous for the mobile reception of DAB-signals where, due to the properties of the transmission channel, a more difficult reception situation exists than in the case of stationary reception. In this way fading disturbances can be corrected.

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[0012]   FIG. 1 is a circuit diagram of the present invention according to a preferred embodiment;

[0013]   FIG. 2 is a graph illustrating an example of weighting and adding for two antenna; and

[0014]   FIG. 3 is a circuit diagram of the present invention according to an alternate embodiment.

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obtained for this receiving channel. The carrier at the frequency f1 is thus weighted with a relatively low weight, for example only with the channel correction value 2, while the carriers in the range below and above the frequency f1, which are received at the full level, are weighted very high, for example with the weight 10. In the case of the antenna A2 this low weighted receiving range lies at a different location at the frequency f2.

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and scope of the invention, and all such modifications as would be obvious to one skilled in the art are intended to be included within the scope of the following claims.

What is claimed is:

#1

Form PTO-1449

ATTY DOCKET NO. 4100=0120P	**APPLICATION NO.** 09/701782

INFORMATION DISCLOSURE CITATION IN AN APPLICATION

(Use several sheets if necessary)

APPLICANT
LAUTERJUNG et al.

FILING DATE December 4, 2000	**GROUP**

U.S. PATENT DOCUMENTS

EXAMINER INITIAL	DOCUMENT NUMBER	DATE	NAME	CLASS	SUB CLASS	FILING DATE IF APPROPRIATE
	5 5 7 9 3 4 3	1996-11-26	Ohmura			
	5 5 3 0 7 2 5	1996-06-25	Koch			
	5 2 6 5 1 2 2	1993-11-23	Rasky et al.			
	3 6 3 3 1 0 7	1972-01-04	Brady			
	5 7 9 9 0 0 5	1998-08-25	Soliman			
	5 7 5 7 7 9 1	1998-05-26	Kanterakis et al.	•		

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FOREIGN PATENT DOCUMENTS

	DOCUMENT NUMBER	DATE	COUNTRY	CLASS	SUB CLASS	TRANSLATION YES
	0 6 0 0 5 4 7	1994-06-08	EUROPE			
	1 9 5 1 8 8 5 8	1996-07-04	GERMANY			abstract
	1 9 6 3 8 4 0 4	1998-02-19	GERMANY			abstract

OTHER DOCUMENTS (Include Name of the author (in CAPITAL LETTERS), title of the article (when appropriate), title of the item (book, magazir journal, serial, symposium, catalog, etc.) date, page(s), volume-issue number(s), publisher, city and/or country where published.

EXAMINER	DATE CONSIDERED 6/18/04

EXAMINER: Initial if citation considered, whether or not citation is in conformance with M.P.E.P. 609; Draw line through citation if not in conformance and considered. Include copy of this form with next communication to applicant.

FP